Topic 3 : Atoms and the Periodic Table

Every element is made up of tiny particles called atoms. The atom consists of a small positively charged **nucleus** surrounded by negative **electrons**. The nucleus contains protons (+ve) and neutrons (no charge). An atom is neutral because the number of protons is equal to the number of electrons. Atoms of different elements have a different number of protons ; this number is called the **Atomic number**.

Atomic number = No. of protons = No. of electrons

Atoms of different elements differ in size and mass. Protons and neutrons have about the same mass (we shall call this mass 'one atomic mass unit' - amu) ; electrons are much lighter.

Mass number = No. of protons + No. of neutrons

Symbols for atoms are written :

$$\begin{matrix}\text{Mass Number}\\ \text{Atomic Number}\end{matrix}\mathrm{X} \qquad \text{e.g.} \quad {}^{12}_{6}\mathrm{C}$$

The mass of this atom is therefore 12 amu.

Isotopes

Isotopes are atoms which have the same number of protons but a different number of neutrons.
They are therefore atoms of the same element. They have the same atomic number but a different mass number.
Most elements consist of a mixture of isotopes.

Example : CARBON

Isotope	No.of protons	No.of neutrons	Atomic No.	Mass No.
$^{12}_{6}C$	6	6	6	12
$^{14}_{6}C$	6	8	6	14

Relative Atomic Mass

Chlorine consists of two isotopes : ^{35}Cl and ^{37}Cl

The average mass of the isotopes is called the Relative Atomic Mass (RAM) or Atomic Weight.

Though Chlorine consists of two isotopes of masses 35 and 37 amu, its relative atomic mass is **NOT** 36 amu ! We need to take account of the relative amount of each isotope present: 75% is ^{35}Cl and 25% is ^{37}Cl. The relative atomic mass of Chlorine is, in fact, 35.5 amu.

Since relative atomic masses are the average masses of all the isotopes, they are rarely whole numbers.

Example : Silicon 92% ^{28}Si
5% ^{29}Si
3% ^{30}Si

RAM = 28.11 amu

Ions

Ions are charged particles.
Negative ions are formed when an atom gains an electron.

Example : the fluoride ion F^- is formed when a Fluorine atom F gains an electron.

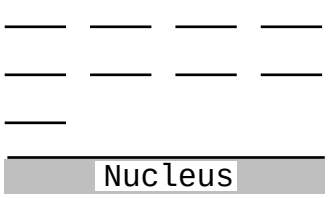
Positive ions are formed when an atom loses an electron.

Example : the sodium ion Na^+ is formed when a Sodium atom Na loses an electron.

Ion	No. of Protons	No. of Electrons
F^-	9	10
Na^+	11	10

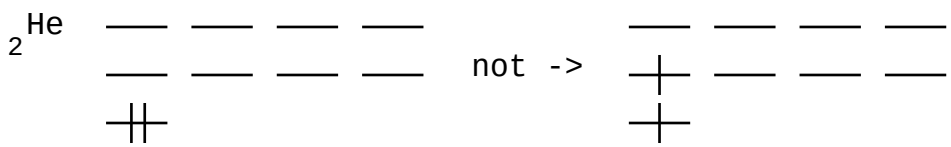
The Electrons

The electrons exist around the nucleus in clouds. Each cloud can hold a maximum of two electrons (electron pair clouds). The electrons are arranged in energy levels ; the nearer the nucleus the lower the energy level.



Within one energy level the electrons keep as far apart as possible by occupying different clouds (electrons repel one another). Sometimes the electron is forced into sharing a cloud when having a cloud of its own would mean moving up to a higher energy level :

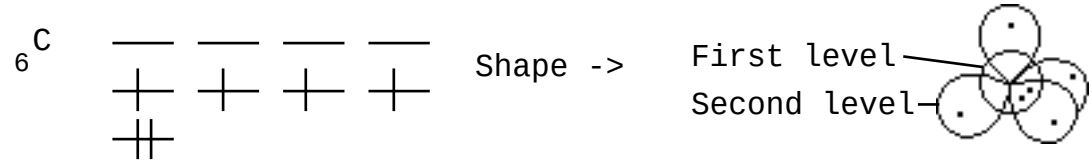
Example : HELIUM



So the electronic structure of Helium is written 2)

More examples :

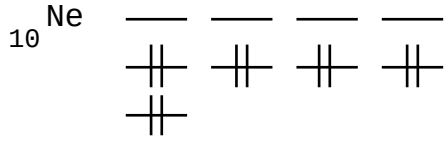
1. CARBON



Electronic structure 2)4

The tetrahedral shape of the four clouds in the second energy level minimises electron repulsions.

2. NEON



Electronic structure 2)8

Classification of Elements

Elements could be classified (grouped together in families) in various ways e.g. solids, liquids and gases or metals and non-metals.

The best way is to place them in groups having **similar chemical properties** (The Periodic Table). The chemical properties of elements depend on the number of unpaired outer electrons (**valency**).

In Group 1 (H, Li, Na etc.) the number of unpaired outer electrons is 1. These elements are called the 'Alkali Metals' because they all react with Water forming alkalis. They are all soft metals with low melting points.

In Group 2 (Be, Mg, Ca etc.) the number of unpaired outer electrons is 2. These very reactive elements are all hard with high melting points.

In Group 7 (F, Cl, Br etc.) the number of unpaired outer electrons is 1. These elements are called 'The Halogens' ; the all react rapidly with metals.

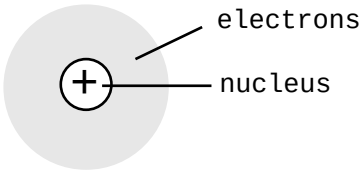
In Group 8 (He, Ne, Ar etc.) the number of outer unpaired electrons is 0. These elements are called the 'Inert' or 'Noble Gases' and are extremely unreactive.

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

The rows **across** the periodic table are called **periods** (e.g. the third period Na -> Ar). Within each period the electrons fill the same energy level. The Sc -> Zn period is known as 'The Transition Elements' ; they have a variable valency.

Topic 4 : How Atoms Combine

The protons in the atom's nucleus attract the electrons which move around it.

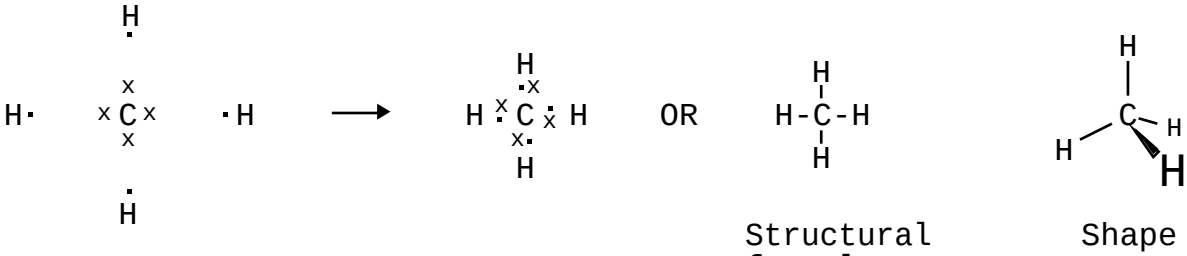


Going from left to right across a period in the periodic table the number of protons in the nucleus increases and so the atom's Electron Attracting Power (EAP) increases e.g. Lithium (3 protons) to Fluorine (9 protons). The periodic table can therefore be divided, by a line running roughly from Boron to Astatine, into two areas : the **metals** on the left with a low EAP and the **non-metals** on the right with a high EAP.

When atoms bond together all their unpaired electrons become paired (the stable electron arrangement). This can be done in two ways :

1. Sharing electrons (Covalent Bonding)

This usually occurs between two non-metals e.g. **Methane**

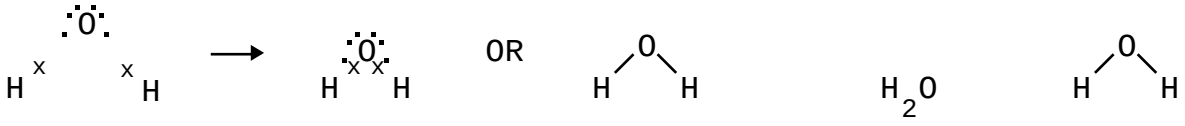


The bonding pair of electrons attract the two positive nuclei holding them together. The molecular formula of Methane is therefore CH_4.

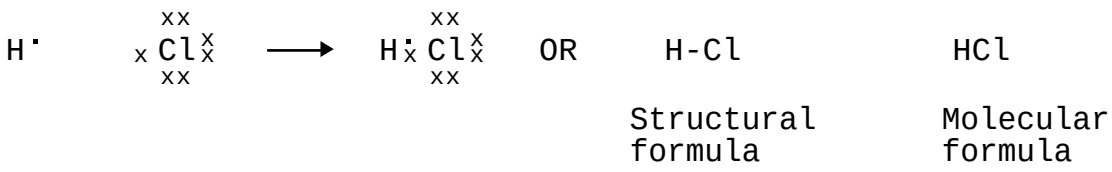
The formula gives the number and types of element in the molecule.

More examples :

(i) **Water**



(ii) **Hydrogen chloride**



HCl is an example of a diatomic molecule : it consists of **two** atoms.

Many elements exist as diatomic molecules e.g.

H_2 Cl_2 F_2 O_2 N_2

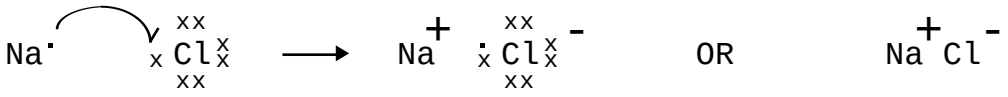
2. Gaining or losing electrons to form IONS

This is called **Electrovalent Bonding** and usually occurs between a metal and a non-metal.

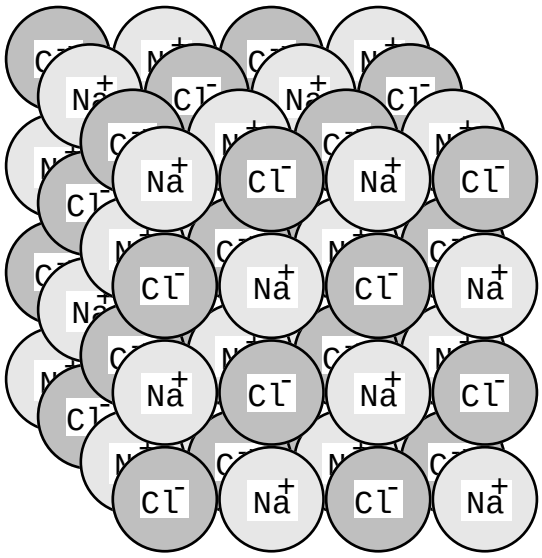
The **METAL** loses electrons because it has a **LOW EAP**.

The **NON-METAL** gains electrons because it has a **HIGH EAP**.

e.g. **Sodium chloride**



Sodium chloride consists of positive sodium ions and negative chloride ions held together by the attraction of unlike charges :



The formula Na^+Cl^- (more usually written without showing the charges : NaCl) gives the ratio and the types of elements bonded together.